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Fact-Checking Climate Change: An Analysis of Claims and Verification Practices by Fact-Checkers in Four Countries

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Abstract

This study examines climate claims by analyzing fact-checked content from four countries. In addition, it investigates several important aspects of professional fact-checking practices including transparency, accessibility, and the use of corrective sources. Findings of this study indicate that fact-checked climate claims from different countries vary by the aspects of climate change they focus on (e.g., existence, causes, impacts, and solutions), types of claim makers, and levels of accuracy. Furthermore, there are differences in fact-checking practices from the four countries with regard to transparency, accessibility, and the use of corrective sources. Theoretical and practical implications of the findings are discussed.

Keywords

climate change, misinformation, fact-checking practices, transparency, accessibility

Since climate change became a prominent topic in 1988 (Oreskes & Conway, 2011), the public has been highly divided about whether or not this environmental phenomenon exists, its causes and impacts, and the solutions to mitigating and adapting to its effects, despite the near-100% consensus on climate change among scientists (Treen et al., 2020; van der Linden et al., 2017). This is mostly because of the proliferation of

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contrarian views and numerous disinformation campaigns that were designed (Oreskes & Conway, 2011) to confuse the public, stall policy changes, and prevent mitigation and adaptation efforts (Treen et al., 2020). In addition, as a complex scientific issue, climate change has frequently been misunderstood and misinterpreted, turning it into a popular topic of rampant misinformation (van der Linden et al., 2017). The Internet, with its transmissibility, and the emergence of social media platforms have exacerbated the problem, furthering the spread of false claims about climate change (Samantray & Pin, 2019).

In recent years, to debunk false claims, increased effort has been devoted to fact-checking and information verification services in multiple countries. The International Fact-Checking Network initiative, which consists of more than 100 fact-checkers from around the world, was launched in 2015, contributing to improving the information ecosystem (Ceron et al., 2021; Lyons et al., 2020). Despite the important role professional fact-checkers play in contemporary media landscape, there is still a dearth of academic research focusing on how claims are made, as well as how fact-checking is practiced with regard to scientific issues like climate change. Even less clear is how climate claim-making and fact-checking practices may differ from country to country. Fact-checking is still professionalizing its practices. Investigating how fact-checkers operate provides us with nuanced understanding of the epistemology of this recently emergent journalism genre (Amazeen, 2013; Dimitrova & Nelson, 2017). Analyzing fact-checked content on claim-making on climate change adds to the literature on public communication on this issue. It furthers our knowledge of the different aspects of how misinformation on climate change is created in order to help counterbalance inaccurate information (Feng et al., 2021) and prevent its damaging effects (Dan et al., 2021) with regard to this environmental phenomenon.

To fill this gap, this study examines the content of fact-checked claims on climate change in the United States, Germany, the United Kingdom, and Australia in the 5 years from 2015 to 2019. This research investigates several aspects of claims on climate change that drew attention from professional fact-checkers to verify. In addition, we assess a few dimensions of fact-checking practices including transparency and accessibility, as well as the use of corrective sources, and compare them between major fact-checkers across the four countries. This study conceptualizes accessibility, arguing that it is an important aspect of professional fact-checking content to engage users. Findings contribute to a growing well of literature on professional fact-checking. In addition, this research provides a snapshot into the situation of misinformation on climate change across the selected countries. These findings could be used as references for professional fact-checkers in solidifying the practices of an emerging profession in the contemporary media environment.

Climate Change Misinformation

Misinformation has become a global concern and has been ranked as one of the top 10 global trends threatening the world (Cook et al., 2018; Lewandowsky et al., 2013). While different scholars suggest varying definitions of misinformation, a common

agreement is that it pertains to information that is false, inaccurate, misleading, and often presented out of context (Treen et al., 2020). Misinformation is sometimes used interchangeably with "fake news" which is defined as fabricated information that mimics news media content in form but not in organizational process or intent (Wardle & Derakshan, 2018). Disinformation, on the contrary, is created to deceive (Fallis, 2015). The key difference between misinformation and disinformation is in the (un) intention of the claim maker, which, in many cases, is impossible to identify. This research does not focus on such a difference between false claims on climate change, although we recognize that both misinformation and disinformation on this environmental issue are common. Our goal is to understand the level of facticity or the lack thereof of climate claims that have been fact-checked by professional fact-checkers from the selected countries. From here on, we use the term misinformation in its broadest sense to refer to false claims which include both misinformation and disinformation.

Misinformation carries an adverse impact on society. Specifically, there is evidence that the presence of misinformation can cause people to stop believing in facts altogether (Lewandowsky et al., 2013). van der Linden (2015) found that exposure to misinformation on global warming reduces people's prosocial intentions (e.g., signing an online petition to mitigate global warming effects or supporting a global warming cause). This is because without expertise and skills in verifying claims, many individuals merely rely on heuristics to substitute for a statement about climate change or other complex scientific issues (Cook et al., 2018) or on fact-checking services.

There are several reasons why climate change has been prone to misinformation. First, false information on climate change comes from well-funded campaigns which aim to disinform the public and policymakers, creating confusion and uncertainties about climate realities (Bramoullé & Orset, 2018). The purpose of these campaigns is primarily to prevent policies on climate change that may hurt business groups whose profits become threatened by stricter regulations. To achieve this goal, these campaigns sow doubts about climate change by undermining the credibility of scientists and science organizations (Oreskes & Conway, 2011). Second, climate change is a complex issue, which deals with a wide range of scientific disciplines (McBean & Hengeveld, 2000). Many of its aspects require highly specialized knowledge and are often incomprehensible to lay audiences. Furthermore, scientists and the news media have been blamed for poor communication of climate change despite the tremendous impacts it has on humankinds (Bell, 1994; Schäfer, 2012). Finally, as a highly contested issue with great political impacts, climate change has been utilized by disinformation bots that aim to further polarize the public in some countries (Marlow et al., 2021). For all of these reasons, climate change has offered a fertile ground for misinformation on this issue to be created and spread.

The growing use of social media and online platforms has fueled the spread of misinformation in general and that on climate change in particular, contributing to the decline of trust in climate science. This indicates the importance of falsehood identification efforts in maintaining a healthy information environment. Of those, fact-checking has proven to be effective in fighting misinformation (Young et al., 2018). For

example, in experiments conducted simultaneously in four different countries, Porter and Wood (2021) found that fact-checks reduce beliefs in misinformation, with effects lasting beyond 2 weeks after the experiments. Thus, much effort has been made into developing fact-checking services across the globe to counter the detrimental effects of misinformation (Young et al., 2018).

Misinformed Aspects About Climate Change

Controversies related to climate change often revolve around its existence, causes, effects, or solutions, which involve political, economic, and scientific complexities (Cappella & Jamieson, 1994; Cook et al., 2018; Nyhan & Reifler, 2010; Vu et al., 2019). Since climate change or global warming began to receive more public attention since late 1980s, falsehoods have been spread around about whether climate change exists. For example, in exploring the hoax discourse by contrarian blogs, Brüggemann et al. (2020) found that questioning scientific evidence about the existence of climate change is a frequently used argument that anticlimate change bloggers employed to put forth the discourse. According to the World Wildlife Fund (n.d.), a global nonprofit environmental organization, of the top 10 common myths about climate change, three are about its existence. They include such statements as (a) the earth's climate has always changed; (b) global warming is not real as it is still cold; and (c) climate change is a future problem. This false information has influenced public members' perceptions of this global environmental issue. In the United Kingdom, for example, a recent survey conducted by the University of Cambridge found that more than one-third of the respondents (35%) incorrectly thought that "Scientists believe the Sun has impacted the Earth's rise in temperature" (Biddlestone & van der Linden, 2021).

In addition to questioning the existence of climate change, the cause of this environmental issue has been a focus of much misinformation (Cook et al., 2018). According to Brandwatch, a social media monitoring company, the top climate change misinformation piece with the largest amount of engagement (e.g., like, share, retweet, comment, and post) in 2020 originated from naturalnews.com, a website that is a purveyor of fake news (Weill, 2019). The piece stated that "NASA admits climate change occurs because of changes in Earth's solar orbit and NOT because of SUVs and fossil fuels," (Reid, 2020, p. 9).

Several studies found erroneous ideas are also about the impacts of climate change, particularly related to the hole in the ozone layer (Lee et al., 2020; Punter et al., 2011). Others discovered that the concepts of solutions were held at a superficial level and featured misconceptions (Lane & Catling, 2016; Lee et al., 2020). There was a general tendency of participants to suggest actions for which they were not personally responsible (Shepardson et al., 2011) and participants believed in scientifically incorrect ideas about solutions, such as using unleaded petrol as a solution to climate change (Kilinc et al., 2009). However, recent surveys showed promising results about public opinions across the world demanding governments to act on the climate crisis (Carrington, 2021). In the United states, where climate change has been a politically contentious issue, a Pew survey found that members of the public increasingly agreed

on various aspects of climate change including its impacts, solutions, and government accountability (Tyson & Kennedy, 2020).

This study aims to provide a snapshot of misinformation on climate change through examining fact-checked content on this issue. It unveils certain aspects of the interactive dynamics in the current information ecology where clashes between disputed claims and verification efforts happen. Not all false claims are debunked by fact-checkers. Selecting what to debunk may involve biases as journalists are influenced by multiple factors in their gatekeeping work (Dimitrova & Nelson, 2017; Shoemaker & Reese, 2013). However, analyzing fact-checked content on climate change arguably offers access to a relevant scope of misinformation. As climate change has been a highly politicized issue with almost every climate action being a political action, much of the discussion on climate change is dependent on the political context of a nation, and that, perhaps, would influence the content of misinformation on climate change in a country as well. Thus, this study asks the following questions:

Research question 1 (RQ1): What aspects (e.g., existence, causes, impacts, and solutions) of climate change does fact-checked information focus on? What are the differences in the focus between fact-checkers from different countries?
Research question 2 (RQ2): To what extent are the claims proven false or true? What are the differences in conclusions of climate claims between fact-checkers from different countries?

Key Actors in Climate Change Misinformation

Climate change is a global phenomenon that influences all facets of the socio-political and economic sphere worldwide. It is clear that skepticism, doubt, and contrarianism often surround climate change misinformation and particular people, entities, and forces of antireflexivity are often at the forefront of denying climate change (Treen et al., 2019).

In review of the literature on climate change actors, Björnberg et al. (2017) identified six categories of actors and organizations that deny environmental science in general and climate science specifically. They found that most denialists are politically conservative white males or organizations that are related to oil or coal extraction, steel, mining, car industries, or right-wing media. Similar patterns were found in Australia and the United Kingdom, but not in Germany (Tranter & Booth, 2015). In the United states, political pundits and fossil fuel, coal, automotive, and electric utility industries are often implicated in stressing uncertainty around climate change (Ding et al., 2011; Dunlap, 2013; Treen et al., 2019). As Dunlap and McCright (2011) further state, conservative U.S. politicians have often shown skepticism toward climate change. Skeptics have often been blamed for the spread of misinformation on climate change.

Misinformation about climate change does not only come from climate skeptics. Climate scientists, supporters of climate change, and even climate computer models have been found to either miscommunicate or exaggerate the effects of it as well,

hence contributing to the diffusion of false information on the issue (The Associated Press, 2021; Friedman, 2019; Fiorina et al., 2008). A U.N. report warned that scientists may need to be careful in modeling the future of climate change effects as some computer models predicted a future that will be too hot too fast, which may undermine the credibility of climate science (Goodwin & Dahlstrom, 2014; Hausfather et al., 2022). Buttigieg, a democratic presidential candidate, in his statement at the *CNN* climate townhall, inaccurately claimed that "we could lose half the world's oxygen because of what's going on in the oceans" (McDonald, 2019, p. 1). Scientists have also pointed out that the term "existential threat," which has been used widely by many democratic politicians and news organizations in the United states, misrepresents and exaggerates the destructive impacts of climate change on life in this planet.

Scholars argued that many other factors can influence how different audience groups trust or doubt climate-related information. For example, Goodwin and Dahlstrom (2014) contended that how scientists communicate climate change can influence audience trust in climate information. Specifically, the communicator's humor, attractiveness, vigorous delivery, or likability can affect audience members who rely on heuristics in determining whom to trust. This strategy, however, may not work on those who use a more critical and analytical approach in evaluating trustworthiness of climate information. As claim makers play an important role in climate change (mis)information, more research is needed to provide detailed analysis of climate claim makers (Treen et al., 2019) as well as whether differences between political contexts of nations would have any implications on climate claim-making. Thus, this study asks the following question:

Research question 3 (RQ3): Who are the claim makers of climate change information that were fact-checked? What are the differences in demographic aspects of climate claim makers from different countries?

Fact-checking

To combat the spread of misinformation and create informed and engaged citizenry, fact-checking organizations like fact-check.org, PolitiFact, and Fact-checker.org were founded (Ceron et al., 2021). Fact-checking sites were first established during the 1988 U.S. presidential election where scholars and news organizations worked together to combat deceptive ads, also known as "Adwatches" or short television news segments that explored the accuracy of candidate ads (Cappella & Jamieson, 1994). By 2000, several independent, nonpartisan fact-checking organizations were launched to provide corrective information for false political claims.

Since the emergence of major fact-checking services such as Fact-check.org, fact-checking interventions have expanded globally (Amazeen, 2020). Over the past 10 years, fact-checking services have taken root in more than 50 countries including Australia, European and Asian countries (Lyons et al., 2020). As such, their practices are still improving and evolving to set professional standards (Robertson et al., 2020). One important aspect in fact-checking work is being transparent. The ethical

guidelines of the International Fact-Checking Network (2021) emphasize transparency as one of the most important criteria in its code of principles. They include being transparent in affiliation, funding, use of sources, and correction policy. However, not all aspects of transparency are detectable to audiences. Recently, Humprecht (2020) found that source transparency is an important aspect in the context of fact-checking. Providing background information on the sources used is crucial and allows fact-checkers to gain credibility, thus reaching a higher number of online users.

Professional fact-checking is a tedious process that cannot keep up with the increasing amount of content posted on multiple digital platforms. The absence of fact-checking services would allow misinformation to spread further. However, even when fact-check warnings are applied to misinformation, their impact does not necessarily reduce lack of trust in the misinformation. A recent poll by Poynter showed that many Americans believe fact-checkers are biased and distrust their corrections (Flamini, 2019). Trust in fact-checking services has been further complicated partly because of a growing distrust in science, news media, and institutions across the world (Fairbrother, 2017; Hmielowski et al., 2014; Lindgren et al., 2022). Like the news media, many fact-checking services have been blamed for their left-leaning political biases, which renders even more distrust from the public, particularly in partisan political contexts (Rogerson, 2013). In addition, most fact-checkers, especially those included in this study (see Table 1), rely on their editorial staff and sometimes reader requests to decide which dubious claims to fact-check. This would allow for bias to influence the fact-checking process and may not accurately reflect the misinformation picture of climate change. In terms of audience, a study by Robertson et al. (2020) suggested that liberal/mainstream news users are more aware of and positive toward fact-checking sites. Conservative news users, on the contrary, find those sites less useful. Based on the findings, the researchers argued that although fact-checkers often claim to be objective and neutral, audiences view them as politically partisan.

Past research has pointed out that the recent rise of fact-checking journalism seems to be a response to the public's growing distrust in media organizations (Dimitrova & Nelson, 2017). However, like in traditional journalism, biases in the fact-checking process are unavoidable as numerous factors can influence journalists in their professional practices. Shoemaker and Reese (2013) suggested a hierarchical model of influences on journalistic practices, which contains factors at five different levels including individuals, routine, organizational, social institution, and social system. These factors can affect fact-checking journalists in multiple ways ranging from selecting fact-checking topics, choosing sources to publishing fact-checked content (Dimitrova & Nelson, 2017).

Regarding investigating how fact-checking services systematically operate, most fact-checking organizations analyze claims through text-based articles and provide evidence to contradict the scrutinized claim (Amazeen, 2013). Increasingly, journalistic organizations are noticing that the use of textual information may not be the most effective way to correct misinformation (Mantzarlis, 2016). Social science research found that informational formats including both text and visual components are the

Table 1. Fact-checkers and Fact-check Items by Country.

Fact-checkers	Country	No. of items	Selection policy	Staff
AAP Factcheck	Australia	18	- Editorial staff select items - Reader request	Paid staff
Conversation	Australia	26	- Editorial staff select items - Reader request	Paid staff
RMIT Factlab	Australia	38	- Editorial staff select items - Reader request	Paid staff
Correctiv	Germany	32	- Editorial staff select items - Reader request	Paid staff
Dw.com	Germany	2	- Editorial staff select items - Reader request	Paid staff
Klimafakten	Germany	3		
Carbon brief	United Kingdom	16	- Editorial staff select items - Reader request	(fact-checkers from different universities and think tank).
Fullfact.org	United Kingdom	28	- Editorial staff select items - Reader request	Paid staff Automated fact-checking
The Guardian	United Kingdom	7	- Editorial staff select items - Reader request	Paid staff
Factcheck.org	United States	110	- Editorial staff select items. Striving for equal selection of Democrats and Republican - Reader requests	Paid staff
PolitiFact	United States	136	- Editorial staff select items. Striving for equal selection of Democrats and Republican - Reader requests	Paid staff
Snopes	United States	74	- Editorial staff select items - Reader request	Paid staff

Note. AAP = Australian Associated Press; RMIT = Royal Melbourne Institute of Technology.

most effective at keeping people's interest and memory recall (Ravetz & Ravetz, 2017). Specifically, those who are politically disinterested or less politically knowledgeable are unlikely to learn or recall the information (Young et al., 2018). In the same study Young et al. (2018) found that videos were more likely to reduce misperceptions and allowed participants to draw correct inferences due to the visual format being perceived as easier to understand compared with text-based fact-checks. Most U.S. fact-checking sites implement visual rating systems or include visual cues such as the PolitiFact's Truth-o-meter. An experimental study by Amazeen et al. (2018) shows that participants preferred truth scales when accessing fact-checked content. However, the effectiveness of truth scales was also affected by partisanship with participants responding more positively to graphical correction formats when the candidate was of the same party as the participant. Truth ratings had no effect when the candidate was from the opposing party. All in all, including elements that help explain fact-checks in a simpler way is important to engaging users and hence makes the content more accessible.

It is widely agreed in journalism studies that the practice of journalism is shaped by culture (Hanitzsch, 2007). For example, American news media have been criticized for portraying climate change as an issue that scientists do not have a consensus. This is mainly because the balance norm, one of the most important professional practices in U.S. newsrooms, requires journalists to include voices from both sides when reporting a contentious issue (Boykoff & Boykoff, 2007). As most fact-checking services are either associated with newsrooms or provided by former journalists, the practices of these services may also be influenced by the journalistic culture of a country. This study inquires into the potential differences in fact-checking practices in four countries by asking the following questions:

Research question 4 (RQ4): To what degree do fact-checkers practice transparency and accessibility in verifying information related to climate change? What are the differences in transparency and accessibility adoption by fact-checkers from the four countries?

Research question 5 (RQ5): What differences exist in corrective source use in fact-checking climate change claims by fact-checkers from the four countries?

Methods

Data Collection

This study used a quantitative content analysis of articles related to climate change and global warming to compare fact-checking sites from different countries. Using several keywords including "climate change" and/or "global warming" on the databases of the fact-checking websites, we retrieved every fact-check article about climate change to collect a total of 490 from 11 fact-checkers in the United states (320), the United Kingdom (51), Germany (37), and Australia (82) from January 1, 2015, to December 31, 2020, (see Table 1). The selection of the four countries was based on several

factors. First, there were large enough numbers of fact-check articles on climate change. Second, language skills of team members were taken into account as we were interested in analyzing the articles in the original languages they were written. The U.S. fact-checks accounted for the majority of the sample, which reflects how politically contentious this issue is in the country, with many claims being made during the nation's political events.

Data Analysis

The unit of analysis is a fact-check article. A codebook with 21 items was developed based on the literature and assessment of the data. Three coders, including two graduate students and one faculty in a journalism program, participated in the coding. Coders went through the training before they started coding 20% of the sample (100 articles). After several rounds of coding and reconciliation, intercoder reliability reached satisfactory levels with Cohen's Kappa coefficients ranging from 0.70 to 0.89, respectively (see Table 2). The articles that did not receive acceptable agreements between coders in the training rounds were reshuffled back to the dataset. The remaining articles (390) were divided equally between the two graduate student coders.

Table 2. Intercoder Reliability.

Variable	Cohen's Kappa coefficients
Aspects of climate change	0.82
Claim maker	
Occupation	0.84
Accuracy of claims	0.70
Transparency	
Embedded links	0.77
Accessibility	
Photograph	0.82
Graphic/chart/table	0.74
Social media	0.75
Visual verdict	0.77
Corrective source	
Report	0.78
Scientist	0.75
Scientific paper	0.84
Authority	0.76
Social media	0.89
News media	0.79
Website	0.84
Other	0.81

Variables and Measurements

The variables and measurements used in this study were either adapted from previous studies (Liu et al., 2011) or built during pilot coding.

Aspects of climate change was adapted from several previous studies (Liu et al., 2011; McCright & Dunlap, 2000). Coders identified whether the claim focused on the existence (e.g., climate change is "a made-up catastrophe"), cause (e.g., humans are not the main contributor to global warming), impacts (e.g., deaths rose to 650 because of heatwaves), or solutions (e.g., climate protectors in Germany now want to ban pets such as dogs and cats or even kill them because they produce too much CO2). An additional coding item was about the credibility (e.g., whether an image was doctored). There was an option for others or unclear.

The *claim maker* variable was coded using one coding item and was measured by performing a Google search on the claim maker. Options were politician, businessperson/organization, scientist, climate activist, celebrity, and the media, social media, or others/unclear. Choices were exclusive. If a claim maker was known for several identities (e.g., celebrity and activist), the one that is more widely known was selected. There was an option for other/unclear.

Accuracy of claims was recorded based on the truth scales fact-checkers used in their content. Some fact-checkers (e.g., Snopes) used very clear scales. Some did not do so. Instead, verdicts could be inferred from the information in the text. Options included false, mostly false, half true/half false/misleading, mostly true, true, and others/inconclusive.

Transparency was operationalized by counting the number of links to external sources.

Accessibility was measured with two variables. One was about whether the fact-check included visual elements in its content to help users with understanding the focused issues. The variable was measured by counting how many photographs, charts, graphics, tables, video, and social media illustrations were included in the fact-checked content. The other was about whether the content provided a clear verdict on the claims. Coders coded "1" if the fact-check article included a visual verdict or clearly stated the verdict in the article's title (e.g., misleading claim) and "0" for non-presence of an accessible verdict.

Corrective source was coded by counting the presence of several source types, including (a) *report* (e.g., reports conducted by NGOs or government agencies that are not peer-reviewed), (b) *scientist* (e.g., researchers and professors), (c), *scientific study* (e.g., peer-reviewed articles from scientific journals), (d) *authorities* (e.g., EPA, IEA, and UNFCCC), (e), *news media* (e.g., mainstream news organizations), (f), *website* (e.g., websites of different organizations), (g) *social media* (e.g., Facebook and Twitter), and an option for others.

Results

RQ1 was about the focused issues in fact-checked content. Of the 490 fact-checked items, 398 (81.3%) involved verifying details related to the four major aspects of

climate change (i.e., existence, cause, impacts, or solutions). Fifty-six (11.4%) were simply about credibility issues such as a doctored image of Greta Thunberg, wrong data being quoted, and miscaptioned events of global warming protesters leaving trash behind. The focus was unclear in 36 (7.3%) fact-checked items. Of the remaining 398, 43% (171) were about climate solutions; 25.4% (101) were concerned with climate existence; 22% (88) were related to climate change impacts; and 9.5% (38) were about the cause of climate change. Chi-square test results revealed significant differences in the focus of the four climate aspects in fact-checking content from the four countries, $\chi^2(15) = 88.56, p < .001$. Standardized residual results indicated that climate change claims from the United States were significantly more likely to be about existence compared with all three countries including Australia and the United Kingdom. Climate claims from Australia were significantly more likely to focus on solutions than the United States and Germany. The U.K. fact-checked content was significantly more likely to be concerned with solutions to climate change than that of the United States. The U.K.'s climate claims, however, were significantly more likely to be about the impacts of climate change than those from the United States, Germany, and Australia (see Table 3).

RQ2 was concerned with truth ratings, or the verdicts fact-checkers made about climate change-related claims. Of the 490 fact-checking articles, 454 (92.7%) reached a conclusion on the claims. Of the 454 claims with a conclusion, more than half (53.1%) were determined as either *false* (192, 39.2%) or *mostly false* (68, 13.9%). More than one-third (31.9%) were either *true* (71, 15.6%) or *mostly true* (74, 16.3%). The rest (10.8%) were *half true/half false.*[1] Kruskal–Wallis *H* tests were used for non-normally distributed data. Results showed that there was a statistically significant difference in between truth ratings by fact-checkers from the four countries, $H(3) = 26.41, p < .001$. Pairwise comparison results with Bonferroni corrections indicated that fact-checkers from the United States were significantly more likely to find false information than those in the United Kingdom ($U = 90.48, p < .001$) and Australia ($U = 43.97, p < .05$) (see Table 3). In sum, the majority of the climate claims were either *false* or *mostly false*.

RQ3 focused on claim makers. Of the 490 claims, 71.8% (352) were from identifiable human or organization sources; 7.3% (36) were from the news media (e.g., CNN); 13.7% (67) were from social media (e.g., Facebook); and; 7.1% (36) were unidentifiable. Of the 352 human and organization claim makers, 81% (285) were politicians; 6% (21) were businesspeople or organizations; 9.94% (35) were scientists; 1.7% (6) were celebrity sources, and 1% (5) were activists. Results from a chi-square test indicated statistically significant differences in types of claim makers by country, $\chi^2(21) = 160.31, p < .001$. According to the standardized residual analysis, politicians were significantly more likely to make claims in fact-checked content from Australia, compared with this claim maker type in the United States, the United Kingdom, and Germany. Climate claims in the United Kingdom were significantly more likely to come from businesspeople/organizations and the news media than those in the United States, Australia, and Germany. Climate claims from German fact-checked content were significantly more likely to come from social media compared with those from

Table 3. Use of Climate Fact-checking Content Elements in the Four Countries.

Content element	United States	United Kingdom	Australia	Germany
Aspects of CC	248 (100%)	47 (100%)	77 (100%)	26 (100%)
Existence	90 (36.3%)	4 (8.5%)	3 (3.9%)	4 (15.4%)
Cause	21 (8.5%)	1 (2.1%)	11 (14.3%)	5 (19.2%)
Impact	57 (23%)	15 (31.9%)	11 (14.3%)	5 (19.2%)
Solution	80 (32.3%)	27 (57.4%)	52 (67.5%)	12 (46.2%)
Truth rating	285 (100%)	51 (100%)	82 (100%)	36 (100%)
True	42 (14.7%)	11 (21.6%)	15 (18.3%)	3 (8.3%)
Mostly true	27 (9.5%)	18 (35.3%)	16 (19.5%)	13 (36.1%)
Half true/half false	33 (11.6%)	5 (9.8%)	11 (13.4%)	0 (0%)
Mostly false	40 (14%)	10 (19.6%)	14 (17.1%)	4 (11.1%)
False	143 (50.2%)	7 (13.7%)	26 (31.7%)	16 (44.4%)
Claim maker	286 (100%)	51 (100%)	81 (100%)	37 (100%)
Politician	194 (67.8%)	24 (47.1%)	61 (75.3%)	6 (16.2%)
Business	12 (4.2%)	5 (9.8%)	4 (4.9%)	0 (0%)
Scientist	20 (7%)	6 (11.8%)	7 (8.6%)	2 (5.4%)
Activist	2 (0.7%)	0 (0%)	2 (2.5%)	1 (2.7%)
Celebrity	5 (1.7%)	1 (1.9%)	0 (0%)	0 (0%)
News media	24 (8.4%)	9 (17.6%)	2 (2.5%)	1 (2.7%)
Social media	29 (10.1%)	6 (11.8%)	5 (6.2%)	27 (73%)
Transparency				
Link use	$M = 19.7$ ($SD = 16$)	$M = 23.1$ ($SD = 18.8$)	$M = 18.93$ ($SD = 11.8$)	$M = 14.6$ ($SD = 11$)
Accessibility				
Visual element	$M = 1.5$ ($SD = 1.6$)	$M = 2.8$ ($SD = 2.6$)	M=3.5 (SD=2.9)	M=3.3 (SD=1.7)
Virtual verdict	208 (65%)	33 (64.7%)	41 (50%)	27 (73%)
Corrective source				
Report	$M = .63$ ($SD = 1.2$)	$M = 1.9$ ($SD = 2.1$)	$M = 2.06$ ($SD = 2.2$)	$M = 1.1$ ($SD = 1.6$)
Scientist	$M = 1.1$ ($SD = 1.9$)	$M = 1.1$ ($SD = 2.6$)	$M = 1.62$ ($SD = 2.3$)	$M = 1.3$ ($SD = 4.1$)
Scientific study	$M = .68$ ($SD = 1.7$)	$M = 1.55$ ($SD = 3.2$)	$M = .8$ ($SD = 1.8$)	$M = 0.92$ ($SD = 1.9$)
Authorities	$M = 2.3$ ($SD = 2.6$)	$M = 2.1$ ($SD = 1.9$)	$M = 2.45$ ($SD = 2.2$)	$M = 1.4$ ($SD = 1.8$)
News media	$M = 1.95$ ($SD = 2.3$)	$M = 2.4$ ($SD = 3.6$)	$M = .82$ ($SD = 1.6$)	$M = .7$ ($SD = 1.3$)
Website	$M = 1.7$ ($SD = 2.4$)	$M = 5.1$ ($SD = 6.2$)	$M = 4$ ($SD = 4.6$)	$M = 5.73$ ($SD = 7.6$)
Social media	$M = .68$ ($SD = 1.4$)	$M = .9$ ($SD = 1.9$)	$M = .65$ ($SD = 1.03$)	$M = 1.5$ ($SD = 2.1$)

Note. CC = climate change.

The table reports frequency of use and mean counts of relevant fact-checking content elements.

the United States, Australia, and the United Kingdom (see Table 3). In short, most climate claim makers were politicians, although Australian fact-checkers tended to select claims by politicians more often than those from the United States, the United Kingdom, or Germany.

RQ4 was concerned with *transparency* and *accessibility* in fact-checkers' practices. The number of links, a proxy for *transparency*, for each of the climate change fact-checks was 19.5 ($SD = 15.42$, $Mdn = 16$). Kruskal–Wallis H test results showed no statistically significant difference in the use of links between fact-checkers from the four countries, $H(3) = 6.86$, $p < .08$.

Accessibility was represented by the number of visual elements in fact-checked content and the existence of a clear verdict in the fact-checked content on climate change. In terms of visual elements used in fact-checked content, descriptive data revealed that more than three-fourths (382, 78%) of the articles included at least one visual element ($M = 2.11$; $SD = 2.17$). Kruskal–Wallis H test results demonstrated a statistically significant difference in the use of visual elements in fact-checked content, $H(3) = 78.96$, $p < .001$, with mean rank values being 206.24 for the United States; 324.9 for Australia, 286.87 for the United Kingdom; and 352.1 for Germany. Post hoc tests with Bonferroni corrections demonstrated that fact-checkers from the United States were significantly less likely to use visual elements in their content than their fellow fact-checkers from Australia ($U = -118.65$, $p < .001$), the United Kingdom ($U = -80.63$, $p < .01$), and Germany ($U = 145.81$, $p < .001$). No significant differences were found between fact-checkers from the other three countries.

Of the 490 fact-checks, more than half (309, 63.1%) included a visually accessible verdict. Results from a chi-square test indicated statistically significant differences in the adoption of accessible verdicts between fact-checkers from the four countries, $\chi^2(3) = 8.14$, $p < .05$. Standardized residual results showed that fact-checkers from Australia were significantly more likely than those from the United States, the United Kingdom, and Germany to use virtual verdicts in their articles. Overall, there was no difference in the degree of transparency in the content of fact-checkers from the four countries. However, fact-checked content from Australia was more visually accessible than that from the United States, the United Kingdom, and Germany.

RQ5 was about the use of different types of corrective sources. Descriptive data showed that of the 490 articles, 213 (43.5%) cited at least one *report* or more. This number was 128 (26.1%) for *scientific studies*; 200 (40.8%) for *scientists*; 372 (75.9%) for *authorities*; 291 (59.4%) for *news media*; 314 (64.1%) for *websites;* and 185 (37.8%) for *social media*. Kruskal–Wallis test results indicated statistically significant differences in the use of four out of six types of corrective sources between fact-checkers from the four countries. Specifically, they were $H(3) = 56.75$, $p < .001$ for *reports;* $H(3) = 8.68$, $p < .05$ for *scientists;* $H(3) = 12.99$, $p < .01$ for *social media;* $H(3) = 39.11$, $p < .001$ for *news media*; and $H(3) = 61.22$, $p < .001$ for *websites. Authorities* and *scientific studies* were the two types of corrective source that did not see statistically significant differences between fact-checkers from the four countries. Pairwise comparisons using Bonferroni corrections showed fact-checkers from the United states were less likely to use *reports* than those from the United Kingdom

($U = -90.76$, $p < .001$) and Australia ($U = -103.3$, $p < .001$). German and Australian fact-checkers were significantly more likely than the United states (Germany versus United states: $U = 96.24$, $p < .001$; Australia versus United states: $U = 88.29$, $p < .001$) and the United Kingdom (Germany versus United Kingdom: $U = 83.27$, $p < .05$; Australia versus United Kingdom: $U = 75.31$, $p < .05$) fact-checkers to use mainstream news media as corrective sources. American fact-checkers were less likely to use *websites* as sources than British ($U = -108.15$, $p < .001$), German ($U = -128.65$, $p < .001$), and Australian ($U = -80.87$, $p < .05$) fact-checkers. In sum, there were differences in the way fact-checkers from the four countries used corrective sources for climate claim verification, with *authorities* being the favorite.

Discussion and Conclusion

This study examined fact-checked content on climate change from four countries including the United states, the United Kingdom, Germany, and Australia. Its goals were to assess different aspects of claim-making and fact-checking practices on climate change, a complex scientific issue. Regarding climate claim-making, this study found that most of the fact-checking items revolved around one of the four aspects (e.g., existence, causes, effects, and solutions) of climate change. The biggest proportion of the claims was about climate change solutions, while the smallest was concerned with climate change causes. Results of this study also indicated differences in the focus of climate claims between the four countries. Specifically, climate claims in the United states tended to focus on the existence of climate change while in Australia, the United Kingdom, and Germany, the majority were about climate solutions. Such differences reflect the emphasis in the discourse on climate change in each of the countries. Perhaps, it is because in the United states, much of the climate discourse and public discussions are still heavily concerned with whether or not climate change exists (Egan & Mullin, 2017), making it a fertile ground for controversies around this aspect of climate change to grow. This finding has important implications on understanding the general climate narratives in each of the countries. It may also be helpful to communication efforts on how to prepare for communication campaigns to raise public awareness of climate change and to help debunk misinformation on this scientific issue.

This research investigated truth scales used by fact-checkers. It found that not all articles in the sample reached a final verdict on whether the claims were true or false. This demonstrates that climate change is a complex scientific issue and that facts related to it are not always black or white. Even among the 454 articles that provided a conclusion on the claims, not all the final verdicts were clearly true or false. Results from this study support previous arguments that fact-checking and verifying information are challenging (Lim, 2018) to arrive at a conclusive verdict. Findings from this research revealed that more falsehoods were found in climate fact-checks from the United states than in those from the other three countries. This may be due to the fact that climate change has been much more contested in the United states. Having yet to

ratify the Kyoto Protocol as well as being one of the world's biggest carbon dioxide emitters, the United states has seen more pressure to lower its emissions, a move that has been met with much resistance from the oil industry, businesses, and conservative politicians (Bulkeley & Betsill, 2013). It is also, perhaps, because American newsrooms are in favor of the balance norm, which requires journalists to include voices from both sides on this polarized issue, allowing for misinformation on climate change to be amplified through the news media (Boykoff & Boykoff, 2007). As such, widening polarization on climate change in American politics has played an important role in the spread of ideologically driven misinformation since this environmental issue has become partisan (Cook, 2019).

According to the results from this research, most climate change claim makers were politicians, with 263 claims they made having a final verdict. Of those, most were identified as either *false* or *mostly false*. This echoes previous findings of how politicized climate change has been in the country (Chinn et al., 2020). Fact-checkers have been known to prioritize checking claims made by politicians who have the power to influence both policymaking and information users (Lim, 2018). The finding also suggests that politicians are major sources of misinformation on climate change, at least within the prominent pieces of misinformation that have caught fact-checkers' attention.

The second goal of this study was to investigate the professional practices across major fact-checkers in the four selected countries. Several aspects were examined, including *transparency*, *accessibility*, and the use of corrective sources. Regarding *transparency*, which was proxied by the number of links to other outside sources, data analysis revealed that most fact-checkers used a relatively large number of links in each of their articles on climate change. Fact-checkers from the United Kingdom were most likely to link their content with outside sources. This finding is different from what Humprecht (2020) found when assessing all types of fact-checked content from several countries including the United states, the United Kingdom, Germany, and Austria. This is an important practice in fact-checking practice. Fact-checking, to its core, is curating information from reliable sources to verify or debunk claims that are controversial or of unclear accuracy. Linking details in the content with original sources being cited/quoted helps make fact-checking more transparent (Humprecht, 2020), hence increasing trust and engagement with fact-check articles.

Accessibility was conceptualized using the presence of a visually accessible final verdict and visual elements (e.g., graphics and video) to explain the details in the content. Findings from this study indicated that most fact-check articles in the sample included a visually accessible final verdict. In terms of using visual elements in the content, most articles included at least one visual element. American fact-checkers were significantly less likely than those in the United Kingdom and Germany to use visuals in their content. As previous research (Pennycook & Rand, 2019; Vu & Chen, 2021) has found when dealing with verifying information in general, users often choose to rely on shortcuts or heuristics that are visually appealing to them rather than making efforts to engage with the content. Thus, including visual elements and visual verdicts will make fact-checked content more accessible.

Analysis of corrective source adoption showed that *authorities* (e.g., UNFCCC and IEA) and scientific studies/scientists were the most frequently used sources in climate fact-checked content across the four countries. This demonstrates that claims about climate change often challenge scientific and policy aspects related to this issue. There were a few significant differences in the use of different types of sources. For example, fact-checkers from Germany and Australia tended to prefer news media as corrective sources, which may, perhaps, help reduce the complexity of their fact-checked content.

This study has several limitations. Although it focuses on fact-checking misinformation on climate change, its findings may not reflect the entire misinformation landscape of this environmental phenomenon as bias coming from multiple levels (e.g., organizations and individual fact-checking journalists) may be unavoidable. This research only compares fact-checking content on climate change in four developed countries; hence, it does not provide a global picture of fact-checking on this environmental issue. Another limitation is that the amount of U.S. fact-checks accounted for a larger share of the data, which may have skewed the results of this study. Future research should expand the scope to include more countries in different parts of the world. Doing so could reveal more interesting information on fact-checking practices in countries with different levels of economic development and different media systems. Testing to see whether different types of content (e.g., having visual content) would have different effects on the audience would provide nuanced understanding of what is best in presenting fact-checks. In addition, interviewing or conducting an ethnographic study with fact-checkers will help explain how and why they practice fact-checking the way they have done.

This study makes several contributions to the fact-checking literature. *First*, its focus on climate change fact-checking helps gain a stronger understanding of misinformation related to this environmental phenomenon, including which aspects of climate change the claims are about, how true/false those claims are, and who the claim makers are. Scientific evidence has shown that climate change is and will be one of the greatest challenges facing humankind. However, limited actions have been taken because in many countries the public is still divided, and governments are under pressure to protect their nations' economic interests instead of preventing climate change (Smith & Mayer, 2019). Controversies around the issue have fueled misinformation, causing public misperceptions. Thus, understanding misinformation on climate change may help to delineate campaigns in raising public awareness of the issue. For example, selecting messages that provide members of the public with corrections of popular misinformation on climate change for awareness campaigns would help counter the effects of falsehoods on this environmental issue. *Second*, in investigating fact-checking practices, this study conceptualizes a crucial aspect of fact-checking content and accessibility. Arguably, making fact-checking content more accessible helps engage information users better, especially with regard to complex scientific issues like climate change. We have operationalized *accessibility* using several indicators (e.g., visual verdict and visual elements) in fact-checking content. If *transparency* has been a widely promoted concept in fact-checking (Humprecht, 2020; International Fact

Checking Network, 2021), *accessibility* has so far received very limited attention in the literature, despite the fact that engagement is especially important in the context of information overload, where users are inundated with so much information that it is difficult to retain their attention (Lee et al., 2017). Thus, these findings contribute to a growing body of literature on fact-checking content and practices.

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Note

1. The majority of fact-checkers used a 5-point scale ranging from false, mostly false, neutral, mostly true, and true. However, some of the terminology they used such as “Pants on Fire” (see politifact.com) were changed and coded into the existing scale (i.e., false).

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